U.S. DEPARTMENT OF ENERGY

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Transformational Energy Research Projects Win $151 Million in Funding

Department of Energy's ARPA-E selects 37 projects to pursue breakthroughs that could fundamentally change the way we use and produce energy

San Francisco, CA - The Department of Energy today announced major funding for 37 ambitious research projects - including some that could allow intermittent energy sources like wind and solar to provide a steady flow of power, or use bacteria to produce automotive fuel from sunlight, water and carbon dioxide.

ARPA-E was originally established under the America Competes Act of 2007. In April of this year, President Obama announced $400 million in initial funding for ARPA-E through the American Recovery and Reinvestment Act.

The $151 million in funding is being awarded through the Department's recently-formed Advanced Research Projects Agency-Energy ("ARPA-E"). ARPA-E's mission is to develop nimble, creative and inventive approaches to transform the global energy landscape while advancing America's technology leadership. This is the first round of projects funded under ARPA-E, which is receiving total of $400 million under the American Recovery and Reinvestment Act.

In announcing the selections, Secretary Chu said: "After World War II, America was the unrivaled leader in basic and applied sciences. It was this leadership that led to enormous technological advances. ARPA-E is a crucial part of the new effort by the U.S. to spur the next Industrial Revolution in clean energy technologies, creating thousands of new jobs and helping cut carbon pollution."

The grants will go to projects with lead researchers in 17 states. Of the lead recipients, 43% are small businesses, 35% are educational institutions, and 19% are large corporations. In supporting these teams, ARPA-E seeks to bring together America's brightest energy innovators to pioneer a low cost, secure, and low carbon energy future for the nation.

Some of the innovative projects selected for awards include:

- **Liquid Metal Grid-Scale Batteries:** Created by Professor Don Sadoway, a leading MIT battery scientist, the all-liquid metal battery is based on low cost, domestically available liquid metals with potential to break through the cost barrier required for mass adoption of large scale energy storage as part of the nation's energy grid. If successful, this battery technology could revolutionize the way electricity is used and produced on the grid, enabling round-the-clock power from America's wind and solar power resources, increasing the stability of the grid, and making blackouts a thing of the past. And if deployed at homes, it could allow individual consumers the ability to be part of a future "smart energy Internet," where they would have much greater control over their energy usage and delivery.
- **Bacteria for Producing Direct Solar Hydrocarbon Biofuels:** Researchers at the University of Minnesota have developed a bioreactor that has the potential to produce a flow of gasoline directly from sunlight and CO2 using a symbiotic system of two organisms. First, a photosynthetic organism directly captures solar radiation and uses it to convert carbon dioxide to sugars. In the same area, another organism converts the sugars to gasoline and diesel transportation fuels. This development has the potential to greatly increase domestic production of clean fuel for our vehicles and end our reliance on foreign oil.
- **CO2 Capture using Artificial Enzymes:** Today's funding will support an effort by the United Technologies Research Center to develop new synthetic enzymes that could make it

easier and more affordable to capture carbon dioxide emissions from power plants and factories. If successful, the effort would mean a much lower energy requirement for industrial carbon capture and significantly lower capital costs to get carbon capture systems up and running. Success of this project could substantially lower the cost of carbon capture relative to current, state-of-the-art amine and ammonia based processes. This would represent a major breakthrough that could make it affordable to capture the carbon dioxide emissions from coal and natural gas power plants around the world.

- **Low Cost Crystals for LED Lighting:** Developed by Momentive Performance Materials, this proposal for novel crystal growth technology could dramatically lower the cost of developing light emitting diodes (LEDs), which are 30 times more efficient than incandescent bulbs and four times more efficient than compact fluorescents. This higher quality, low-cost material would offer significant breakthroughs in lowering costs of finished LED lighting, accelerating mass market use, and dramatically decreasing U.S. lighting energy usage. Lighting accounts for 14 percent of U.S. electricity use.

ARPA-E was originally established under the America Competes Act of 2007. In April, President Obama announced $400 million in initial funding for the agency. The projects unveiled today are part of the first solicitation from ARPA-E's $400 million in total Recovery Act funding. The 37 selected projects, which are receiving an average of approximately $4 million each, span the energy sector, including potentially transformative innovations in energy storage, biofuels, carbon capture, renewable power, building efficiency, vehicles, and other energy technology areas.

Inspired by the Defense Advanced Research Projects Agency (DARPA), ARPA-E was created to support high risk, high reward energy research that can provide transformative new solutions for climate change and energy security.

This first ARPA-E solicitation was highly competitive and oversubscribed, with over 3,600 initial concept papers received. Of those, approximately 300 full applications were requested and ultimately 37 final awardees through a rigorous review process with input from multiple review panels composed of leading U.S. energy science and technology experts and ARPA-E's program managers. Evaluations were based on the potential for high impact on ARPA-E's goals and scientific and technical merit.

The project selections announced today can be found in the table below.

Lead Research Organization (Partner Organizations)	**DOE Grant Amount**	**Lead Organization Location**	**Project Description**
1366 Technologies Inc. (Massachusetts Institute of Technology - Lab for PV Research)	$4,000,000	Lexington, MA	***Renewable Power*** (solar) "Direct Wafer" technology to form high efficiency "monocrystalline-equivalent" silicon wafers directly from molten silicon, with potential to halve the installed cost of solar photovoltaics.
Agrivida, Inc.	$4,565,800	Medford, MA	***Biomass Energy*** Cell wall-degrading enzymes grown within the plant itself that are activated after harvest, dramatically reducing the cost of cellulosic biofuels and chemicals
Arizona State University (Fluidic Energy, Inc.)	$5,133,150	Tempe, AZ	***Energy Storage*** A new class of metal-air batteries using ionic liquids, with many times the energy density of today's lithium-ion batteries. Could enable long range, low cost plug-in hybrid and all-electric vehicles.
Arizona State University (Diversified Energy,	$5,205,706	Tempe, AZ	***Direct Solar Fuels*** Cyanobacteria that produce and secrete fatty acids for biofuel feedstock using just

North Carolina State University)			sunlight, water, and carbon dioxide as inputs.
Ceres, Inc.	$4,989,144	Thousand Oaks, CA	***Biomass Energy*** Genes that enable energy crops to produce more biomass using less land (and lower quality land), less water, and less fertilizer than standard energy crops. This approach would provide sustainable biofeedstocks to displace oil and coal for fuels and power production.
Delphi Automotive Systems LLC (International Rectifier, Oak Ridge National Laboratory)	$6,733,386	Kokomo, IN	***Vehicle Technologies*** New power electronics technology based on a Gallium Nitride on Silicon process with innovative thermal management that can enable up to 50% more efficient power delivery from batteries to electric motors.
E.I. du Pont de Nemours and Company (Bio Architecture Lab)	$9,000,000	Wilmington, DE	***Biomass Energy*** Production of bio-butanol, an advanced biofuel, from macroalgae (seaweed). Seaweed is a potentially sustainable and scalable new source of biomass that doesn't require arable land or potable water.
EaglePicher Technologies LLC (Pacific Northwest National Laboratory)	$7,200,000	Joplin, MO	***Energy Storage*** High energy, low cost planar liquid sodium beta batteries for grid scale electrical power storage. Could enable continuous power from renewable resources, like wind and solar, and could support a highly stable and reliable grid.
Envia Systems (Argonne National Laboratory)	$4,000,000	Hayward, CA	***Energy Storage*** High energy density Lithium-ion batteries with 3x better energy density than current batteries. Based on novel nano silicon-carbon composite anodes and manganese composite cathodes discovered at Argonne National Laboratory. Could lower the cost and speed the adoption of plug-in hybrids and electric vehicles.
Exelus, Inc. (Zeolyst International, Linde Process Plants)	$1,000,000	Livingston, NJ	***Conventional Energy*** A novel catalyst to convert the olefins in refinery off-gas, which is currently flared and lost, into high-octane alkylate fuel. Could enable recovery up to 45 million barrels per year of gasoline.
FastCAP Systems Corporation (MIT)	$5,349,932	Cambridge, MA	***Energy Storage*** A nanotube enhanced ultracapacitor with energy density approaching that of standard batteries, but with many times greater power density and thousands of times the cycle life. Could greatly reduce the cost of hybrid and electric vehicles and of grid-scale storage.

FloDesign Wind Turbine Corp.	$8,325,400	Wibraham, MA	***Renewable Power*** (wind) A new high efficiency shrouded wind turbine able to deliver significantly more energy per unit of swept area. Could also reduce noise and safety concerns, enabling distributed wind applications.
Foro Energy, Inc.	$9,151,300	Littleton, CO	***Renewable Power*** (geothermal) A new hybrid thermal/mechanical drilling technology for much faster drilling with less wear and tear on the drill bit. Could open up cost effective access to the geothermal energy in deep, hard basement rock, a potentially huge new source of domestically available, carbon-free baseload power.
General Motors Company (University of Michigan, HRL Laboratories, LLC, Dynalloy, Inc.)	$2,655,174	Warren, MI	***Vehicle Technologies*** A shape memory alloy (SMA) energy recovery device to convert waste heat from car engines into electricity. Could significantly increase fuel efficiency in cars (most energy is lost as heat) and could be used in many other heat recovery applications.
Inorganic Specialists, Inc. (Ultramet, Inc., EaglePicher, Southeast Nonwovens, EMTEC)	$1,999,447	Miamisburg, OH	***Energy Storage*** A silicon-coated carbon nanofiber paper for the anode of next generation Lithium-ion batteries. These low cost, manufacturable batteries could accelerate the deployment of plug-in hybrids and electric vehicles, shifting U.S. transportation energy from imported oil to the grid.
Iowa State University (Purdue University)	$4,373,488	Ames, IA	***Direct Solar Fuels*** Metabolic engineering and synthetic biology approaches to increase lipid production, carbon dioxide uptake, and thermal tolerance of algae for the production of biofuels directly from sunlight and CO2. Could make algae-based biofuels production economically viable.
ITN Energy Systems, Inc. (MAG Industrial Automation Systems, EPRI, Colorado School of Mines)	$4,986,249	Littleton, CO	***Building Efficiency*** Solid-state electrochromic film on plastic substrates with roll-to-roll production process to substantially reduce the cost of electrically controlled smart windows for net-zero energy buildings. These windows reduce heating and cooling loads and minimize overhead lighting use.
Lehigh University	$566,641	Bethlehem, PA	***Carbon Capture*** Electric field swing adsorption for carbon capture using high surface area conductive solid carbon sorbents. Uses electric fields to change the interaction of molecules on a surface, capturing and

			then releasing the CO2 using far less energy than current approaches.
Massachusetts Institute of Technology	$6,949,624	Cambridge, MA	***Energy Storage*** An all liquid metal grid-scale battery for low cost, large scale storage of electrical energy. This new class of batteries could enable continuous power supply from renewable energy sources, such as wind and solar and a more stable, reliable grid.
Michigan State University	$2,540,631	East Lansing, MI	***Vehicle Technologies*** The wave disc engine, a gas-fueled electric generator that is five times more efficient than traditional engines for electricity production, as well as lighter and cheaper to manufacture. Could replace current generators for plug-in hybrid electric vehicles.
Momentive Performance Materials (Soraa, Advanced Photonic Crystals)	$4,519,259	Strongsville, OH	***Building Efficiency*** A high-pressure ammonothermal process for the inexpensive production of high quality, single crystal GaN substrates at high crystal growth rates. Could allow production of light emitting diodes (LEDs) at costs equal to current low-cost fluorescent lighting. LED lighting consumes as little as one tenth of the energy of current lighting options.
Nalco Company (Argonne National Laboratory, Argonne, IL USA)	$2,250,487	Naperville, IL	***Carbon Capture*** An electrochemical process for CO2 capture using Resin-Wafer Electrodeionization. Uses pH changes to adsorb and desorb CO2 from flue gas without energy intensive, costly processes such as heating or a vacuum.
NanOasis Technologies, Inc.	$2,031,252	Richmond, CA	***Water*** Carbon nanotubes for reverse osmosis membranes that require less energy and have many times higher flux. Could dramatically reduce the cost and energy required for desalination to supply fresh water for our crops and communities.
Ohio State University (PSRI, CONSOL Energy, Inc., Shell/CRI, The Babcock and Wilcox Company)	$5,000,000	Columbus, OH	***Carbon Capture*** Syngas Chemical Looping (SCL) to convert coal or biomass into electricity while efficiently capturing the CO2. Has successfully been demonstrated at laboratory scale; this project will scale it up to a pilot plant at the National Carbon Capture Center.
PAX Streamline, Inc. (Georgia Tech Research Institute)	$3,000,000	San Rafael, CA	***Renewable Power*** (wind) "Blown Wing" technology for wind turbines. Creates a virtual airfoil by jetting compressed air along a wing. Can be dynamically adjusted to maximize power under a wide range of wind

			conditions. A new design that can be manufactured at a fraction of the cost.
Pennsylvania State University (Sentech Corporation)	$1,900,067	University Park, PA	***Direct Solar Fuels*** Catalyst-coated titanium dioxide nanotube membranes to convert sunlight, carbon dioxide and water into methane and other hydrocarbon fuels.
Phononic Devices, Inc (University of Oklahoma, California Institute of Technology, University of California at Santa Cruz)	$3,000,000	Norman, OK	***Waste Heat Capture*** A new class of high efficiency thermoelectric devices and materials that use thermally insulating semiconductors with high thermal-to-electric conversion efficiencies. An astounding [60%] of U.S. energy is lost in the form of waste heat - from power plants, industrial processes, and vehicles. High efficiency thermoelectrics hold great promise to tap into this vast hidden energy resource while reducing U.S. greenhouse gas emissions.
Porifera Inc. (University of California Berkeley, Lawrence Livermore National Laboratory)	$1,077,992	Hayward, CA	***Carbon Capture*** Carbon nanotubes integrated into polymer membranes to increase the flux of CO2 capture membranes by two orders of magnitude. Could enable much less expensive carbon capture from coal plants.
RTI International (Archer Daniels Midland Company, ConocoPhillips, Albemarle Corporation)	$3,111,693	Research Triangle Park, NC	***Biomass Energy*** A single-step catalytic biomass pyrolysis process with high carbon conversion efficiency to produce a stable bio-crude "oil" with low oxygen content. The approach combines pyrolysis oil production, stabilization, and upgrading into one process.
Stanford University	$4,992,651	Stanford, CA	***Building Efficiency*** Sensors, software, and controls to track and improve energy use patterns. Could lead to substantial reductions in building energy use by changing human behavior through timely information and usable controls.
Sun Catalytix Corporation	$4,085,350	Cambridge, MA	***Direct Solar Fuels / Energy Storage*** A novel catalyst to greatly enhance the efficiency of splitting water into hydrogen and oxygen. An important platform technology for the production of solar fuels and for distributed energy storage systems.
United Technologies Research Center (Hamilton Sundstrand, CM-Tech,	$2,251,183	East Hartford, CT	***Carbon Capture*** Synthetic enzymes for capturing CO2 from coal plant flue gas streams. Uses a synthetic form of the enzyme carbonic anhydrase, which our bodies use to remove CO2.

Inc., Worley-Parsons, Columbia University)			Could dramatically reduce the cost of carbon capture.
Univenture, Inc. (Rockwell Automation, Ohio University, Case Western Reserve University)	$5,992,697	Marysville, OH	***Biomass Energy / Direct Solar Fuels*** A novel algae harvesting system that could dramatically reduce the energy cost necessary to harvest, dewater, and dry algae by using a novel absorbent moving belt harvester. This technology offers the potential to transform the economics of algae-based biofuel production by removing a major barrier to large scale commercialization.
University of California, Riverside	$760,705	Riverside, CA	***Vehicle Technologies*** Alkaline polymer electrolyte fuel cell membranes that eliminate the use of expensive catalyst materials. Potential to drastically reduce fuel cell costs and enable their widespread application in building and automotive applications.
University of Delaware (University of Nebraska-Lincoln, Northeastern University, Virginia Commonwealth University, Ames Laboratory, Electron Energy Corporation)	$4,462,162	Newark, DE	***Vehicle Technologies*** Novel high energy density, low rare-earth content magnetic materials with double the energy density of current materials. Would decrease the weight and increase the efficiency of motors for hybrid, plug-in hybrid, and electric vehicles and generators for advanced wind turbines. Also could greatly reduce U.S. imports of key rare-earth elements that are not domestically available.
University of Illinois (MC10, Inc.)	$1,715,752	Urbana, IL	***Waste Heat Capture*** A novel thermoelectric waste heat harvesting device based on large area arrays of 1-D concentric silicon nanotubes. Can be inexpensively printed as stacked thermoelectric junctions. This low cost thermoelectric technology holds great promise to allow the U.S. to begin to harvest the more than 60% of its energy that it loses in the form of waste heat.
University of Minnesota (BioCee, Inc.)	$2,200,000	St. Paul, MN	***Direct Solar Fuels*** Production of liquid hydrocarbon transportation fuels directly from sunlight, water and CO2 using an artificial symbiotic colony of photosynthetic cyanobacteria and Shewanella, a hydrocarbon producing bacteria.

A second set of ARPA-E funding opportunities will be announced in the late Fall. Please visit www.arpa-e.energy.gov for more information about these selections, upcoming technical workshops, and new funding opportunities.